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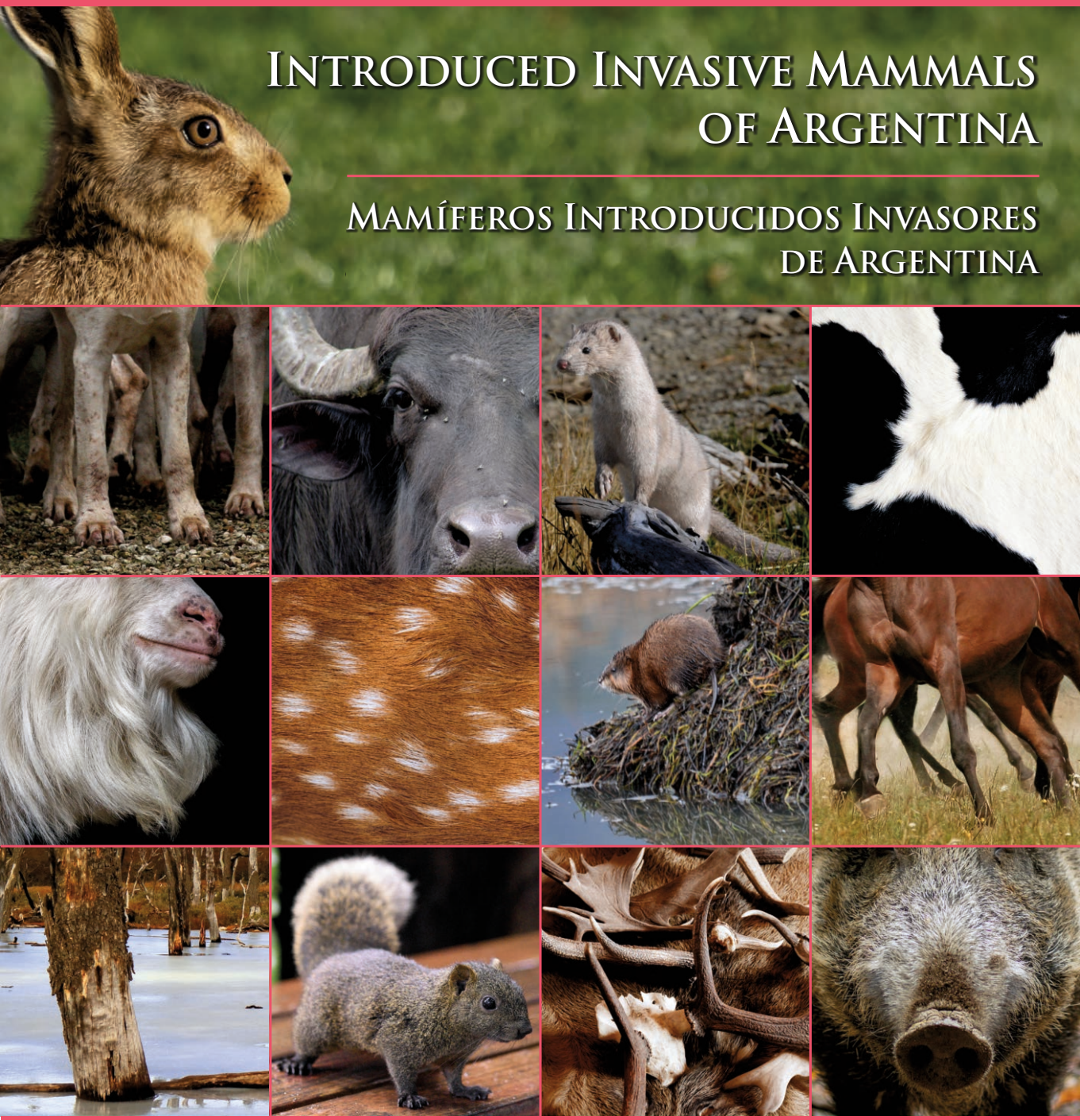
Volume 3

Introduced Invasive Mammals of Argentina

Mamíferos Introducidos Invasores de Argentina



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The Argentine Society for the Study of Mammals (Sociedad Argentina para el Estudio de los Mamíferos – SAREM) was created in 1983, and currently has about 300 members from several countries. SAREM is an interdisciplinary society of natural sciences professionals whose main goals are the promotion of scientific and technical research, the consolidation of national collections and research centers, and the publication and diffusion of research on living and/or extinct mammals. SAREM has organized scientific meetings for mammal researchers since 1994, publishes the journals *Mastozoología Neotropical* and *Notas sobre Mamíferos Sudamericanos*, and has edited books on the systematics, distribution and conservation of the mammals of southern South America, including *Libro Rojo de los mamíferos amenazados de la Argentina* (first ed. 2000, second ed. 2012) and *Mamíferos de Argentina. Sistemática y distribución* (2006), as well as contributing to the *Libro Rojo de los mamíferos y aves amenazados de la Argentina* (currently out of print).

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Introduced Invasive Mammals of Argentina

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Introduced invasive species are a major driver of local to global environmental change, including important negative impacts on biodiversity, ecosystem processes, economies, health and other social values. At the same time, however, different social actors can hold diverse representations of these species, particularly of introduced invasive mammals (IIMs). Such divergent values and perceptions can lead to conflicts regarding the management of IIMs, but also invite researchers and managers to be reflexive regarding their own work at a more fundamental level. Therefore, it is key that we advance towards a holistic understanding of IIMs and develop strategies to manage them based on solid technical information and plural perspectives regarding their multiple values. Despite a rich history of initiatives in Argentina to study and manage IIMs, until now there has not been an opportunity to assess the state-of-the-art knowledge in our country. This book seeks to provide rigorous, relevant and legitimate information to support research, policymaking and management decisions regarding IIMs in Argentina. With this objective in mind, the book presents a series of chapters selected to highlight priority topics concerning the conceptualization and implementation of IIM research and management. Then, fact sheets are provided for the different IIMs found in Argentina. Finally, beyond the realm of academic inquiry, the timing of this publication is ideal to re-enforce policy and decision-making, such as the recently approved National Invasive Exotic Species Strategy, which seeks to implement actions and enhance institutional capacities related to invasive species management in Argentina, and the Convention on Biological Diversity's new Global Biodiversity Framework, which also addresses biological invasions as part of broader efforts to attain the 2050 Vision for Living in Harmony with Nature.

Dr. Alejandro E.J. Valenzuela
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Editors, Vol. III SAREM Series A

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Foreword

Biological invasions by introduced species are one of the great changes rapidly transforming the globe today, with innumerable impacts on economics, human health, ecosystem services, and biodiversity. Mammals are among the most impactful of invasive species, transmitting diseases to humans, livestock, and native animals, trampling native grasslands, voraciously devouring vegetation from groundcover to saplings of forest trees, fouling water, causing erosion, and preying on and outcompeting native animals. They were among the first species humans introduced worldwide and in Argentina, both deliberately (*e.g.*, livestock) and inadvertently (*e.g.*, rats and mice). They have been introduced for sport (*e.g.*, deer, boar) and companionship (*e.g.*, cats, dogs), or simply as attractive ornamentals (*e.g.*, squirrels). Some that are meant to be kept in captivity, such as cats, dogs, and squirrels, escape and establish feral populations.

Argentina looms large in the history of biological invasions by introduced mammals. The earliest permanent European settlers of Buenos Aires in 1580 discovered huge herds of feral horses already on the pampas, and soon after, Vázquez de Espinoza described feral horses in Tucumán that were "in such numbers that they cover the face of the earth…". Many sheep were in Tucumán as well at that time, and of course later sheep were enormously numerous in Patagonia, effecting huge changes in the vegetation and driving land degradation and desertification to this day. When Charles Darwin visited the La Plata region in 1832 during the voyage of the Beagle, he reported that "…countless herds of horses, cattle, and sheep, not only have altered the whole aspect of the vegetation, but they have almost banished the guanaco, deer and ostrich. Numberless other changes must likewise have taken place; the wild pig in some parts probably replaces the peccari; packs of wild dogs may be heard howling on the wooded banks of the less-frequented streams; and the common cat, altered into a large and fierce animal, inhabits rocky hills."

Approximately 40 mammals have been introduced to South America, of which 25–30 have established populations; most of these are in the Southern Cone. In Argentina, I count 23 successfully introduced mammal species, including feral cats, dogs, and cows. Many, such as rats, rabbits, boar, and goats, are widely distributed around the world. By contrast, the hairy armadillo has been introduced nowhere else but from the mainland of Patagonia to Tierra del Fuego Island. Strikingly, except for the rats and house mouse, all these mammals were brought to Argentina deliberately; this is very different from, say, introduced insects. A few of these invasive mammals, like the squirrel, were not intended to be released, but I hesitate to term such invaders truly "accidental," because the people who brought them should have realized that escapes or later releases were almost inevitable. Of course, almost all of these mammals were introduced before the late twentieth century, which was when most scientists and the public began to recognize the extent and importance of impacts of introduced species. However, the squirrel and armadillo introductions were recent enough that potential impacts should have been foreseen. Things could be worse, of course—mammals deliberately brought to Argentina that either were released, but did not establish persistent populations or have not yet escaped from hunting preserves include reindeer, silver fox, mule deer, African buffalo, white-tailed deer, Père David's deer, thar, barbary sheep, wisent, mouflon, chamois, and ibex.

The technology of eradicating introduced invasive mammals has made enormous strides in the last thirty years—at least 31 mammal species have been eradicated from islands worldwide, including relatively large islands like South Georgia. Both Norway and ship rats have been eradicated hundreds of times, and house mice about 100 times. Most large mammals, such as deer and horses, are technologically easier eradication targets—many can simply be tracked and shot, for instance. However, mammals more than any other introduced species pose the complication that many people—especially hunters—simply do not want to eradicate them, and many animal welfare advocates, even those recognizing the damage some invaders cause, object to eradicating them by the only currently feasible means—killing them, humanely if possible. Even rat eradication has been impeded on animal rights/animal welfare grounds, and free-ranging dog and cat populations frequently are seen more as animal welfare issues than as conservation problems to broad sectors of some societies. In Argentina, the problem of implementing feasible eradication programs for invasive mammals is epitomized by the rather schizophrenic attitude taken by the National Parks Administration (Administración de Parques Nacionales – APN) towards red deer. The APN's conservation imperative is supported by the section of Law #22,351 that forbids propagating introduced animals, yet red deer, known to damage native species and ecosystems, are managed in Lanín National Park to foster ongoing hunting, and even to improve the size and quality of the deer for better hunting trophies. Additionally, there is often inconsistent and inadequate funding for managing and eradicating invasive mammals in protected areas, almost always constituting a supervening impediment even when a rational and effective goal is stated.

Argentine scientists have participated heavily in the rapid growth of modern invasion science since its inception in the 1980s, and they and overseas colleagues have conducted substantial research on the biology and impacts of many of the introduced invasive mammals in Argentina, as well as other invasive species. Some of the threats posed by these mammals have even become widely known to the general public in Argentina and beyond—the spread of the beaver from Tierra del Fuego to the mainland has been an international news story. *Introduced Invasive Mammals of Argentina* is therefore an exciting and timely addition to the literature on invasions in southern South America for both the Argentine public (and its political representatives and environmental managers) and scientists worldwide. The many authors assembled for this book explore how these biological invasions happened in the first place, how they spread, what they do to biodiversity, ecosystems, and human enterprises, what has been done about them so far, what can be done about them now, and what might be done with them in the future. The editors and authors are to be congratulated for an excellent exposition of the Argentine part of a growing global phenomenon.

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Chaetophractus villosus
large hairy armadillo, peludo

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Resumen. *Chaetophractus villosus* o «peludo» (Xenarthra – Chlamyphoridae) es una especie de armadillo cuya distribución se extiende desde el Gran Chaco de Bolivia y Paraguay hasta el sur de la provincia argentina de Santa Cruz y las provincias chilenas de Bío Bío y Magallanes. Presenta hábitos cavadores, es omnívoro generalista y puede ocupar una gran variedad de ambientes: pastizales, sabanas, bosques e incluso campos degradados por la actividad agropecuaria. Es una especie claramente favorecida por la actividad del hombre dado que puede aprovechar ambientes modificados, alimentarse de ganado y en basurales, y ha ampliado su distribución hacia el sur gracias a ello y a los puentes sobre los ríos. Es la especie más ampliamente distribuida en Argentina; en tiempos recientes ha ocupado toda la Patagonia y en 1982 fue introducida en la Isla Grande de Tierra del Fuego, en la zona de la Bahía San Sebastián, cruzando así el Estrecho de Magallanes. Estudios genéticos determinaron que todos los individuos de esta única ola de colonización pertenecen al mismo linaje mitocondrial, es decir que poseen una gran reducción de la variabilidad genética en la población. Sin embargo su viabilidad y éxito son innegables. Para 2005 la especie ocupaba unos 484 km² en una zona de explotación petrolera en la costa de la mencionada bahía, con tuberías calientes soterradas para el transporte de los hidrocarburos extraídos (una ventaja dado el clima fueguino y los hábitos cavadores del peludo). Actualmente ocupa una superficie aproximada de 8000 km² que incluye grandes zonas sin tuberías calientes, lo que evidencia su definitiva aclimatación a las condiciones de la región. *C. villosus* no posee depredadores conocidos en Tierra del Fuego y se presume que su presencia allí podría tener impacto sobre varias especies nativas de roedores, aves y el único reptil. Esto tiene sentido dado que en su distribución continental preda sobre anfibios, reptiles, y pichones y huevos de aves, por la distribución que presenta en la Isla Grande y por evidencias indirectas de sus hábitos de forrajeo en el suelo y uso de hábitat en dicha isla. Aunque el peludo *C. villosus* debe ser considerado una especie exótica establecida en Tierra del Fuego, es necesario realizar estudios dirigidos a evaluar su impacto ecológico y económico en el delicado ambiente insular fueguino.

General description of the species

Armadillos are native and typical components of Neotropical faunas associated with temperate climates, historically grouped into the family Dasypodidae. According to a proposal based on mitochondrial DNA, this family should only include long-nosed armadillos or mulitas (*Dasypus*), while the other armadillo species would be part of the family Chlamyphoridae (Gibb *et al.*, 2016), including the large hairy armadillo or peludo (*Chaetophractus villosus*; Fig. 1). This case brings up a classic, but enriching disagreement between genetic versus morphological evidence, both of which have contributed to develop scientific knowledge about phylogenetic relationships of many species.

Figure 1. *Chaetophractus villosus*. (Photo: Leopoldo Soibelzon).

The armadillo's diversity decreases toward higher latitudes; only two species have colonized the Patagonia region: the pichi (*Zaedyus pichiy*) and *C. villosus*. The distribution of the latter in Argentina extends from the Gran Chaco of Bolivia and Paraguay to the southern part of Santa Cruz province, while in Chile it is found from Bío Bío to Magallanes provinces (Atalah, 1975; Wilson and Reeder, 1993). It is the armadillo with the broadest distribution in Argentina, and also includes Tierra del Fuego province (TDF), where it was introduced in 1982 (Poljak *et al.*, 2007). *C. villosus* inhabits diverse environments, such as grasslands, savannas and forests, and also cultivated and degraded fields, such as those used for cattle pasture (Abba and Superina, 2010). Large hairy armadillo individuals reach sexual maturity at an age of one year old, breed during spring, and females give birth to one to three young per litter once a year, after about 10 weeks of gestation. Among the human uses of this species, in a large part of its distribution it is captured for food and in some regions

as material to build string instruments (*charangos*) (Aguiar and Fonseca, 2008). In addition, it can be hunted as a pest species in agricultural areas and may also be killed on roads and by dogs (Abba and Cassini, 2008).

Armadillos have a low body temperature and low basal metabolic rate in relation to their body mass, which are adaptations for burrowing habits (McNab, 1979, 1980, 1985). Burrows provide more stable thermal conditions to cope with environmental temperature fluctuations, and in the case of *C. villosus*, this advantage is combined with a low degree of diet specialization (Redford, 1985) that gives it a remarkable plasticity to inhabit regions with diverse climates and food resources. This plasticity is clearly evidenced by the species' distribution range, including TDF where the average annual temperature is 2–3 °C lower than the continent. The presence of large hairy armadillo on this island again raises questions related to the colonization strategies and impact of introduced species on TDF. Thus, the climate would not be an impediment to the distribution of *C. villosus* to the south, but water barriers, such as the Magellan Strait, could be sufficient obstacles to stop its dispersal (Deferrari *et al.*, 2002; Poljak *et al.*, 2007). This hypothesis would explain why this species colonized Patagonia so recently and quickly, crossing the main rivers due to growing anthropic activity, as proposed by Abba *et al.* (2014), and having an increased home range due to a shortage of food resources (Poljak *et al.*, 2010).

History of the invasion

This armadillo species was introduced to the southern part of San Sebastián Bay in 1982. This is an area of intense oil and gas exploitation. Eight individuals brought from Buenos Aires province were introduced for aesthetic reasons in a ranch located to the northwest of Río Grande city, and an unknown number of animals were introduced by an oil drilling crew from Santa Cruz province for consumption as food (Poljak *et al.*, 2007). Subsequent phylogeographic study revealed the genetic relationship between the TDF population with individuals from the Pampean ecoregion (Buenos Aires and La Pampa provinces) and Santa Cruz province (Poljak *et al.*, 2010), which agrees with the purported origins. This study also revealed that a single mitochondrial lineage colonized all of Argentinean Patagonia and the Argentine portion of TDF. A subsequent study suggested that the same single mitochondrial lineage may have also invaded Chilean TDF (Poljak *et al.*, 2020).

Patterns of expansion and current distribution

To facilitate the transport of extracted hydrocarbons to storage tanks, oil pipelines in TDF are heated at 70 °C, even 90 °C during winter, given the low prevailing temperatures in the archipelago. This could have helped the initial establishment and expansion of the large hairy armadillo on the coast of San Sebastián Bay, since almost all the burrows are exactly located on the lines where the above-mentioned pipes are buried (Poljak *et al.*, 2007). Since its introduction in 1982, the distribution of the species increased to 484 km² until 2006 (Poljak *et al.*, 2007). Recent studies revealed that the current distribution is of 8,527 km², seventeen times larger (Poljak *et al.*, 2020). Expansions of the distribution range

were mainly to the west and in a northwest/southeast direction, along the marine coast, probably due to the predominance of loose sandy soils.

The same Patagonian steppe environment where the grasslands of *coirón* (*Festuca* sp.) are abundant, extends about 6,000 km² to the north of the current known invasive distribution of *C. villosus* in TDF. Therefore, it is reasonable to assume that the species is also present there or will be in a short time. Of note, no oil exploitation is in areas where this species expanded its distribution (Poljak *et al.*, 2020). This strongly suggests that the species exceeded the initial obstacles of its biological invasion on the island (see Lizarralde *et al.*, this volume). Predation on newborn lambs and the use of middens by peludos as a source of food in the region (Abba and Cassini, 2008) are undoubtedly also causes of the settlement and expansion of the species. Currently, the large hairy armadillo's distribution in TDF is growing and given the outdated records of its presence in the south of Chile (Fig. 2;

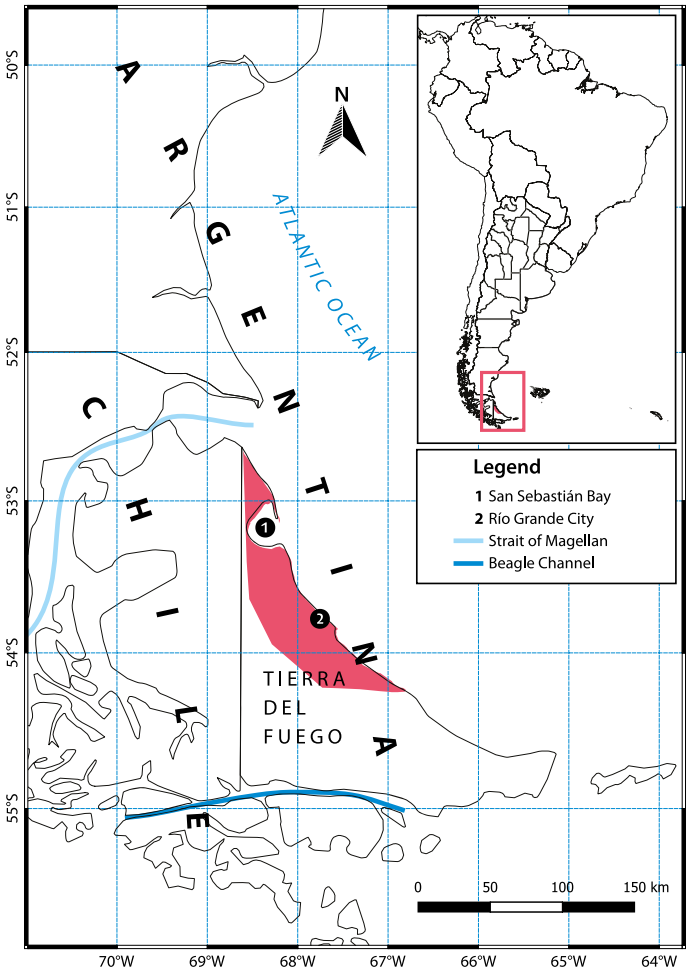

Figure 2. Distribution of *Chaetophractus villosus* in Argentina. Modified from Gallo *et al.* (2019). (Mapping: Ian Barbe and Alfredo Claverie).

Cabello *et al.*, 2017; Poljak *et al.*, 2020), new explorations would be important to deepen the understanding of biogeographical studies, including the Chilean portion of TDF. In addition, these studies would complete the distribution map of the large hairy armadillo; and clarify the patterns of expansion and genetic relationships of the TDF population with the continental populations on both sides of the Andes mountains.

Impacts

Poljak *et al.* (2007) mention that the life history traits of *C. villosus* overlap with those of native species in the area of San Sebastián Bay, particularly related to the choice of spaces to build its burrows that coincide with *Ctenomys magellanicus*, also called the *tuco-tuco*. This is particularly concerning because this native rodent is considered vulnerable (Lizarralde and Escobar, 2000). On TDF, the armadillo's foraging area also overlaps with that of the migratory buff-necked ibis (*Theristicus caudatus*), which digs holes in the ground to feed at similar depths as the large hairy armadilllo. In spite of these potential impacts, there are no specific studies that have quantified competition or interactions between or other species. Preliminary data obtained in the areas around heated oil pipelines indicate that *C. villosus*' diet includes roots, beetles and other insect larvae and *calafate* fruits (Poljak *et al.*, 2007). In its continental range, this species also feeds on small vertebrates (*e.g.*, amphibians, reptiles and pigeons) and eggs (Redford, 1985).

It should also be noted that coastal area of San Sebastián Bay is part of an internationally recognized Ramsar wetland (Provincial Law #415/98 TDF, Argentina), which includes the protection of waterfowl habitat. Plus, it is the natural habitat of the Magellanic lizard (*Liolaemus magellanicus*), a lizard species which is the only reptile native to TDF (Úbeda and Grigera, 1995; Lavilla *et al.*, 2000). Therefore, it is reasonable to consider that *C. villosus* presence in the area is a potential risk for the conservation of these species. It should also be noted that Cossa *et al.* (2021) reported the predation of a large hairy armadillo on an upland goose (*Chloephaga picta*) nest in Santa Cruz province, indicating its ability to impact this species which is also native to TDF and nests on the ground.

In its native range, the large hairy armadillo is a very low frequency diet item for fox species found on the continental steppe. However, there is no evidence that invasive Pampa fox (*Lycalopex gymnocercus*), which is the only species that inhabits TDF grasslands, feeds on it (Medel and Jaksic, 1988). On the other hand, in contrast to the cultural, social and economic values that *C. villosus* has along its continental distribution, it is not a species used by the inhabitants of the Fuegian steppe, perhaps for being a new component in the region. Both situations could be favoring the establishment of this species on TDF: from an ecological point of view, due to the fact that there is apparently a lack of predator pressure, and from a socio-cultural one, because it is not a species exploited as a resource.

Management

C. villosus has acclimatized and settled in TDF. Its geographical distribution has increased from 484 km² in 2005 to 8,527 km² in 2020 and must be considered as an

established introduced species for TDF (Poljak *et al.*, 2020). This shows that the species can survive without specific conditions created by anthropic activities (*e.g.*, associated with gas pipelines) and supports the claim that the species is in an "expansion phase" of its biological invasion (as proposed by Cabello *et al.*, 2017). To date, there are not systematic management plans.

Additionally, although there is evidence of predation over birds and mammals in other parts of the large hairy armadillo's distribution, there is no direct evidence of this kind of interactions with native species of TDF. Therefore, studies to assess the ecological and economic impact of *C. villosus* in TDF's environment are needed.

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